MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2016/2017

ENT4046 – NANO/MICROELECTROMECHANICAL SYSTEMS
(N/MEMS)

7 MARCH 2017
9:00 – 11:00 am
(2 Hours)

INSTRUCTION TO STUDENT

1. This examination paper consists of 5 pages with 4 questions only.
2. Answer all questions.
3. Please print all your answers in the Answer Booklet provided.

QUESTION 1

(a) By means a simple diagram briefly describe the applications of sensor and actuator as input and output transducers in a controlled circuit. [6 marks]

(b) (i)Name the possible energy domains for signal transduction. [3 marks]

(ii) By means of a flowchart, describe the signal transduction in Figure Q1(a) in laser energy measurement. Explain what is the purpose of piezoresistive bridge circuit ?

[5 marks]

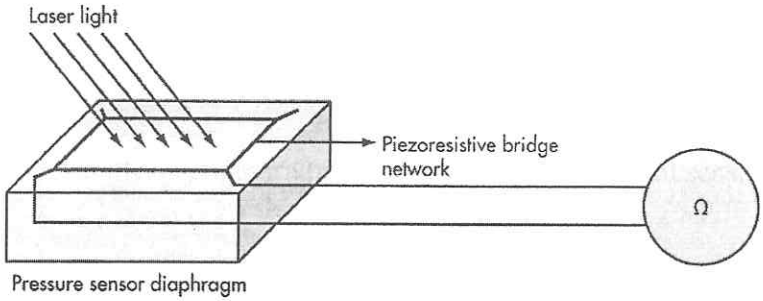

Figure Q1(a)

(c) An autonomous car depends heavily on sensors and detection systems, as shown in Figure Q1(b). Briefly describe the roles of these sensors/system (1)-(5) and the need of a (6)central computer. [5x2 + 1 marks]

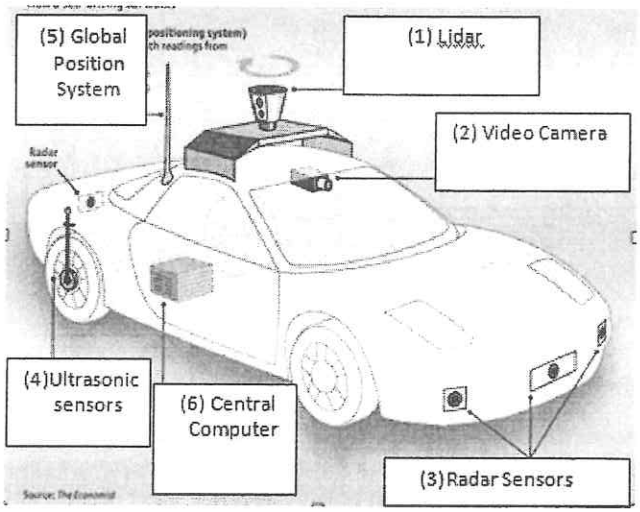

Figure Q1(b)

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QUESTION 2

(a) A microoptomechanical infrared receiver contains a focused plane array of pixels, each of which consists of a bi-meterial cantilever beam and a plate for infrared absorption, as shown in Figure Q2(a).

(i) Briefly explain the working principle of the infrared microsensor. [3 marks]

(ii) Suggest a suitable fabrication method. [2 marks]

(iii) Describe fabrication steps for each pixel of infrared thermal sensor. [6 marks]

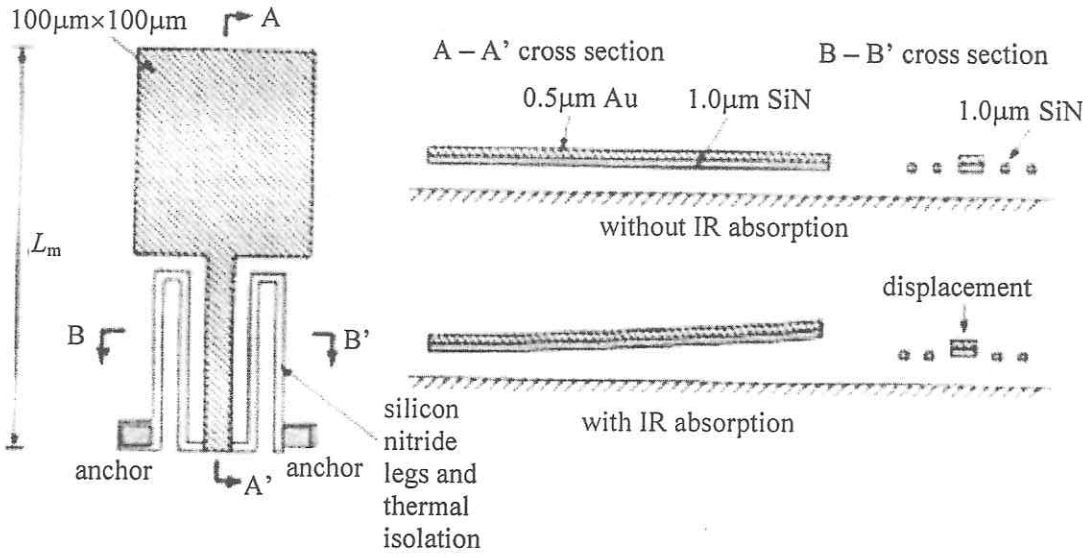

Figure Q2(a)

(b) A microactuator made of bilayer strip which consists of a 1000μm silicon beam with an oxide layer of equal thickness. A resistance heating film is deposited on this oxide-silicon bilayer strip. When the resistance film is heated to temperature T, the estimated interfacial force (F) and the curvature (ρ) of the deformed oxide-silicon bilayer strip are given by, respectively,

$$F = \frac{(\alpha_2-\alpha_1)T}{3} \frac{hb}{\left(\frac{1}{E_1}+\frac{1}{E_2}\right)} \quad \text{and} \quad \rho = \frac{2h}{3(\alpha_2-\alpha_1)T}$$

where and are coefficients of thermal expansions of silicon dioxide layer and oxidized silicon respectively, and are their Young's moduli, h and b are thickness and width of the bilayer strip.

(i) Given that E_1 =385GPa, E_2 =190 GPa, $\alpha_1 = 0.5\text{x}10^{-6}/\text{C}^\circ$, $\alpha_2 = 2.33\text{x}10^{-6}/\text{C}^\circ$, h = 10μm and b =5μm, calculate F and . Comment on F. [8 marks]

(ii) Derive a simple expression so as to calculate the amount of movement of the free end of the strip. [4 marks]

(c) Comment on the thermal conductivity of materials in submicrometer scales. [2 marks]

Continued...

QUESTION 3

(a) A parallel-plate capacitor shown in Figure Q3(a) is suspended by two fixed-guided beams, each with length, width, and thickness as l, w, t, respectively. The material is polysilicon, with Young's modulus of E =120 GPa and l =400μm, w = 10μm, t =1μm. The gap between two plates is 2μm and the area is 400x400μm.

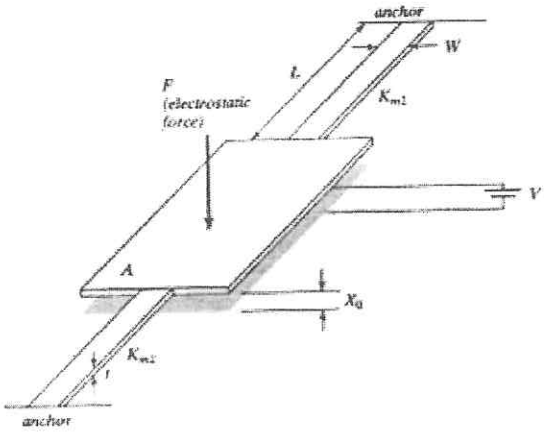

Figure Q3(a)

The vertical displacement (d) and the moment of inertia (I) are given as

$$d = \frac{Fl^3}{12EI} \quad \text{and} \quad I = \frac{wt^3}{12}.$$

If a voltage of 0.4 volts is applied to the parallel-plate capacitor, electrostatic force is produced, calculate

(i) force constant K_{m2}, [3 marks]

(ii) pull-in voltage $V_p = \frac{2x_o}{3}\sqrt{\frac{k_{m2}}{1.5C_o}}$ where C_o is static capacitance, [6 marks]

(iii) Determine the vertical displacement d. [3 marks]

(b) Figure 3Q(b) shows an interdigitated finger capacitor, or a comb-drive.

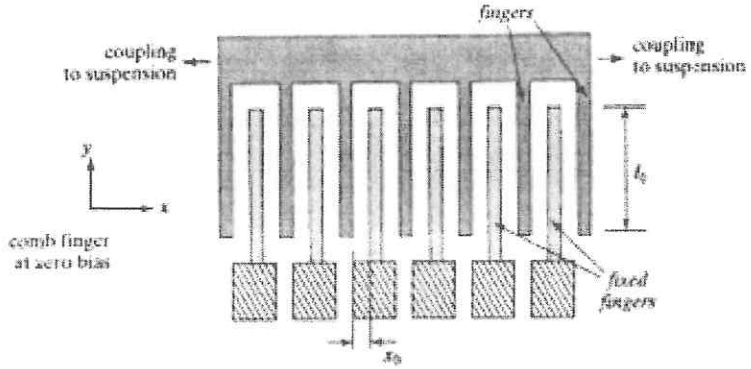

Figure Q3(b)

(i) Design the transverse and longitudinal comb drives. [4 marks]

(ii) Calculate the total capacitance. [3 marks]

(iii) Calculate the displacment sensitivity of transverse comb drive when used as a sensor, and the force when used as an actuator. [6 marks]

Continued...

QUESTION 4

(a) (i) Define the Trimmer Force Scaling Vector. [2 marks]

(ii) Estimate the associate changes in the acceleration (a) and the time (t) and the power supply (P) to actuate a MEMS component if its weight is reduced by a factor of 10. [6 marks]

(b) (i) By means of a simple diagram, describe the three levels of MEMS packaging. [3 marks]

(ii) What are major reliability issues for the Level (1+2) packaging of MEMS, or microsystem? [3 marks]

(iii) Briefly describe what are interfaces in microsystem packaging? [3 marks]

(iv) Briefly describe what are the four reasons for the high cost of MEMS or microsystem packaging. [4 marks]

(c) Suggest the common materials required for microsystem packaging as listed in Table Q4 below: [4 marks]

Table Q4

Microsystem Components	*Available Materials*
Die	
Insulators	
Die Bonding	
Wire Bonding	

End of Paper